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## THE MEXICAN SHEARTAIL (*DORICHA ELIZA*): MORPHOLOGY, BEHAVIOR, DISTRIBUTION, AND ENDANGERED STATUS

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**ABSTRACT.**—We reviewed morphological variation, taxonomic status, geographic distribution, ecology, and behavior of the poorly known hummingbird, the Mexican Sheartail (*Doricha eliza*), based on museum specimens and field studies. Although the broadly disjunct distribution of the species would suggest that two taxa are involved, morphological differences between the populations appear minor, not deserving of formal taxonomic recognition. Ecological differences between the two populations are stronger, however; modeled ecological niches are nearly nonoverlapping, and ontogenetic and behavioral differences may exist. We recommend that, given its extremely restricted distribution, the Veracruz population be considered critically endangered, whereas the Yucatan population be designated as having a restricted range and accorded near-threatened status. *Received 9 February 2001, accepted 22 July 2002.*

**RESUMEN.**—Se revisaron la variación morfológica, estatus taxonómico, distribución geográfica, ecología y conducta de un taxón muy poco conocido, el colibrí tijereta mexicano (*Doricha eliza*), en base en estudios de campo y en museo. A pesar de que la amplia disyunción en su distribución geográfica sugiere la existencia de dos taxones diferentes, la diferenciación morfológica es mínima y no amerita reconocimiento taxonómico formal. Sin embargo, las diferencias ecológicas entre las dos poblaciones son más marcadas, con nichos ecológicos modelados que casi no se sobrelapan, y diferencias ontogenéticas y de conducta pueden existir. En general, la población de Veracruz debe ser considerada en peligro de extinción, mientras que la población de Yucatán debe ser designada de distribución restringida y con un estatus de conservación de casi amenazada.

Although the endemic Mexican Sheartail

(*Doricha eliza*) has been known for more than a century, little is known of this hummingbird's natural history. Its nest was only recently discovered and described, and the details of its geographic distribution are only now being understood (Ortiz-Pulido et al. 1998). Its generic placement is in question (e.g., Howell and Webb 1995, Johnsgard 1997, Ortiz-Pulido et al. 1998, American Ornithologists' Union 1998). The general picture, nevertheless, is one of a rare species with two disjunct populations, one in central Veracruz, and the other along the northern fringe of the Yucatan Peninsula (Howell and Webb 1995). Both populations are found in arid veg-

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etation, but the Yucatan population is more concentrated in the lowlands of coastal regions than that of the Veracruz population (Ortiz-Pulido et al. 1998).

Studies of other disjunct taxa generally have found clear sets of distinguishing characters, often at the level of species (Banks 1990, Peterson 1993, Garrido et al. 1999, Peterson and Navarro-Siguenza 2000). The two populations are thought by some to constitute recognizable taxonomic entities, in particular based on differences in the coloration of the collar (K. C. Parkes pers. comm.). The state of knowledge of these populations was so poor that the Veracruz population even was thought possibly extinct. Herein, we compare the two populations of *Doricha eliza* in terms of phenotypic, ecological, and behavioral variation. We also document the ecological and geographic distribution of the forms, leading to a reassessment of the conservation status of the species.

## METHODS

To permit comparisons, we requested loans of specimens from scientific collections with holdings of the species (Appendix); in addition, MBR and GES collected a series of specimens of the Yucatan population, and deposited them at the Univ. of Kansas Natural History Museum (KUNHM) and the Museo de Zoología, Facultad de Ciencias, Univ. Autónoma de México (MZFC). We measured exposed culmen, wing length, and tail length (outermost and innermost rectrices) on each skin, and made comparisons of coloration in direct sunlight. Because measurements were not normally distributed, we used Mann-Whitney *U*-tests (Zar 1996) to test population differences for significance.

We made detailed observations of each disjunct population, recording food plants and describing behavior when possible. MBR and GES studied the Yucatan populations from 24 February to 1 March 1998 (18 km east of Dzilám de Bravo; 21° 28' N, 88° 34' W; 0 m elevation), at the ecotone between mangrove and deciduous tropical scrub. ROP and RD carried out systematic surveys of the Veracruz population during June, August, October, and December, 1998, searching a rectangular area of about 3,200 km<sup>2</sup> (96° 58' to 96° 25' W, 19° 03' to 19° 45' N) in central Veracruz, based on records from the literature (American Ornithologists' Union 1998, Howell and Webb 1995, Ortiz-Pulido et al. 1998) and unpublished sight records (H. Gómez de Silva, S. Aguilar, and E. Ruelas pers. comm.). No reliable record known to us places the species outside of this zone. We chose a total of 20 sites within this area, based on elevation (five sites per 300 m of elevation, ranging 0–1,500 m), spaced by 10–20 km.

During June 1998, we searched a 40 × 2,000 m transect at each site for hummingbirds. During August and October we searched another 20 transects focused within the more limited area within which the species had been encountered on the June searches. Methods for transect surveys followed established techniques (Emlen 1971, 1977).

We obtained additional distributional data from the *Atlas of the distribution of the birds of Mexico* data base (Peterson et al. 1998), based on the Mexican holdings of 43 museum collections in North America and Europe (listed in the Acknowledgments). We geo-referenced all distributional data by direct inspection of maps and displays using ArcView (vers. 3.1) GIS software.

We developed ecological niche models for the two populations of Mexican Shearwater based on associations between point occurrence data and quantitative geographic coverages (including potential vegetation type; Rzedowski 1978), elevation, annual mean temperature, and annual mean precipitation (Comisión Nacional para el Uso y Conocimiento de la Biodiversidad, available at <http://www.conabio.gob.mx/>). Several approaches have been used to approximate species' ecological niches, including BIOCLIM (Nix 1986) and logistic multiple regression and generalized linear modeling (Austin et al. 1990). We employed the *Genetic Algorithm for Rule-set Prediction* (GARP), which includes both of the above methods and others in an iterative, artificial intelligence-based approach (Stockwell and Noble 1992, Stockwell 1999, Stockwell and Peters 1999). Individual algorithms were used to produce component "rules" in a broader rule-set, and hence portions of the landscape may be identified as inside or outside of the niche based on different algorithms. GARP therefore represents a superset of the other approaches, and should generally have greater predictive ability than any one of them. Extensive testing of GARP has indicated excellent predictive ability for species' geographic distributions (Peterson and Cohoon 1999; Peterson et al. 1999, 2000, 2001, 2002a, 2002b; Peterson 2001; Peterson and Vieglais 2001; Anderson et al. 2002; Stockwell and Peterson 2002a, 2002b). Ecological niche models were then projected back onto geography to predict potential distributional areas for each population.

## RESULTS

We found no indication of differences in morphometric characters between the two populations. We examined 18 specimens (14 males, including 3 from Veracruz, and 4 females, 2 from Veracruz; Appendix). We found no significant differences in any morphometric character (all *P* > 0.05), nor did patterns of variation suggest consistent size or shape differences. Means for the four characters (adult males only, all measurements in mm) were for Veracruz (*n* = 2) and Yucatan (*n* =

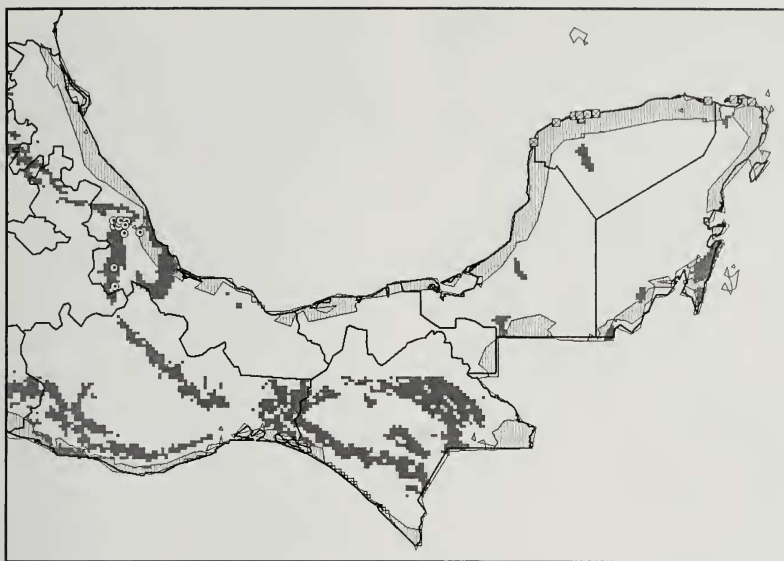


FIG. 1. Distribution of the Mexican Sheartail (*Doricha eliza*). Circles (with dots) indicate known occurrences of the Veracruz population, and squares (with x's) indicate occurrences of the Yucatan population. Potential distributions are shown in gray (Veracruz population) and vertical hatches (Yucatan population).

7), respectively: exposed culmen, 20.3 (range 19.6–21.0) versus 19.6 (19.0–20.8); wing length, 36 (35–37) versus 35.8 (34–37); outermost rectrices, 37 (36–38) versus 35.8 (35–38); and innermost rectrices, 24.5 (24–25) versus 24.4 (24–26).

Color characters also were closely similar in the two populations. At first inspection, adult Yucatan males appeared to differ from Veracruz males in having a white, rather than creamy, collar caudal to the gorget. Yucatan adult females also appeared to differ subtly in having underparts off-white, rather than buffy white, and Yucatan males appeared to have more bulbous, racquet-shaped tips to the tail than males from Veracruz. With more careful inspection, however, all color differences could be attributable to age variation, and differences in feather shape to feather wear. Hence, differences between the populations appear negligible, at least based on the small series of specimens presently available.

The ecological distribution of the two populations, however, is quite distinct. The Yucatan population is found exclusively in a narrow (ca 1 km) zone along the coast, particularly focused along the ecotone between mangroves and tropical deciduous forest. In

contrast, the Veracruz population was far (25 km) from the coast, mainly in undisturbed arid vegetation (82% of observations). Indeed, about 30 years of field work by numerous observers at the Biological Station La Mancha nearby on the Veracruz coast have failed to produce a single credible record of the species (Ortiz-Pulido et al. 1995).

GARP models showed clearly the disjunct ecological distributions of the two populations, as well as only minimal corridors for movement of individuals (Fig. 1). The Yucatan population was modeled as inhabiting areas with 0–350 m elevation, precipitation broadly across all nine categories, and temperatures in only the three hottest categories, whereas the Veracruz population was modeled as inhabiting areas with 300–2,250 m elevation, precipitation in only the driest five categories, and temperatures in the three intermediate categories. Interpredictivity of the two ecological models, which would indicate identity of ecological niches (Peterson et al. 1999), is nil. Hence, the two forms of *Doricha eliza* are distinct in ecological dimensions.

Sex ratios in the two populations may differ, although the evidence is equivocal. The Yucatan population appears heavily biased to-



ward individuals with female-like plumage, perhaps an 8:1 ratio. During February 1998, we observed in an area of about 6.5 km<sup>2</sup> (18 km east of Dzilam de Brave, Yucatan) four adult (in definitive plumage) males and 30–35 female-plumaged birds. We observed no such bias in Veracruz, where searches revealed a 1:1 ratio for 22 individuals observed. This difference may suggest true differences in sex ratio or plumage sequences, but could easily result from different timing of field efforts for the two populations (i.e., the post-breeding observations in Yucatan may have detected more immatures than observations in Veracruz, which were later in the year).

During the study we observed known immatures in both populations. We collected two immatures in Yucatan. The first (KU 89385), collected on 26 February 1998, was a male with bursa of Fabricius, 12 colored feathers on the throat, and no grooves along the bill. The bill condition suggests that this individual was more than 9–12 months old (Ortiz-Crespo 1972). The second (KU 89386), collected on 26 February 1998, was a recently fledged (bill only 50% of adult length) male with no colored throat feathers that was being fed by a female-plumaged individual. We observed two immatures in Veracruz. The first, observed 7–8 November 1998, was a male about two months old, given that it was being fed by a female-plumaged individual. He remained perched on a twig for about 6 h, permitting careful observation. This male had colored throat feathers; presence of such feathers on such a young male might suggest that adult male plumage may be attained during the first year in the Veracruz population, reflecting differences in ontogenetic trajectories of the two populations. This evidence, however, is only circumstantial and more extensive information will be required before a credible conclusion may be drawn. The second immature, observed 21 March 1999, was a female-plumaged bird that was being fed by another female-plumaged individual.

We observed sheartails feeding at several plants. In Yucatan, sheartails fed primarily at viny, pink-flowered terrestrial plants of the genus *Ipomoea* (Convolvulaceae), and less frequently at small, terrestrial red flowers of the genus *Justicia* (Acanthaceae). In Veracruz, we saw sheartails forage on seven or eight plant

species, most with red flowers: *Malvaviscus arboreus* (Malvaceae), *Hamelia patens* (Rubiaceae), *Salvia coccinea* and *S. purpurea* (Labiatae), *Triumfeta speciosa* (Tiliaceae), *Bouvardia ternifolia* (Rubiaceae), *Stenocereus griseus* (Cactaceae), and possibly *Solanum tridynamum* (Solanaceae).

We observed in Veracruz what appeared to be courtship behavior between members of a pair. For more than an hour we observed the pair chasing each other among the branches of shrubs and a tree, at times noisily. The male chased the female, and she would retreat to the center of a bush, about a meter above the ground. The male followed her, and began to display in front of her. The display consisted of holding his body in a horizontal position in the air in front of her, lifting his tail, and flaring out the red feathers of his gorget. All this time he hovered in the air, with head held still, and the body swaying left and right rapidly. During this display, he produced an intense *rrr-rrr-rrr-rrr* noise, which more or less coincided with the shifting of the body from side to side and lasted about 10 s. Howell and Webb (1995), apparently referring to the Yucatan population, reported that males in courtship move forward and backward in front of the perched female, with the body held vertically, climb to 30 m, and return to perch next to the female. We observed climbs and dives only once (May 2000) in the Veracruz population, and not clearly in a courtship context.

We observed a total of 22 individuals in Veracruz. The distribution of *Doricha eliza* in Veracruz is restricted to an elliptical area of about 40 × 20 km within the Barranca de Naolinco (Fig. 2). Population density in this region is only 0.033 individuals/ha (16 individuals on 480 ha of transects, with 6 individuals seen off transects). Although this density likely varies across the distributional area, extrapolating to the entire 800-km<sup>2</sup> distribution of the population yields an estimate for the entire Veracruz population of only about 2,500 individuals. The Barranca de Naolinco zone is relatively well conserved, given that much of the area is not suitable for most human activities; slopes are steep and the valley floor is covered with a heavy lava flow that prevents cultivation (ROP pers. obs.). Nevertheless, this zone is beginning to be used for grazing goats.

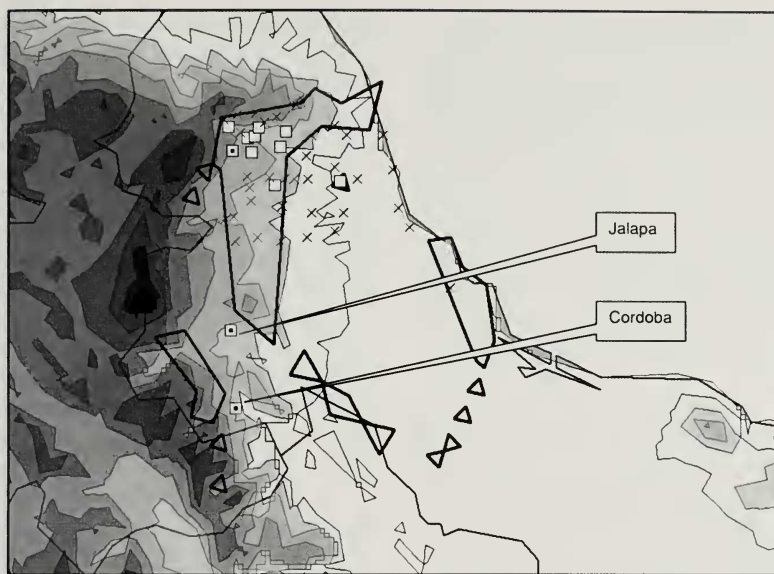


FIG. 2. Distribution of the Veracruz populations of the Mexican Sheartail (*Doricha eliza*). X's indicate sites surveyed without detecting the species, and squares indicate sites where the species was detected. Dotted squares indicate specimen localities, suggesting the imprecise nature of the earliest localities ("Jalapa" and "Cordoba"), but the correct descriptor of the more recent specimen ("5 mi N Jalapa"). Bold lines enclose areas predicted to be appropriate for the Veracruz population based on detailed ecological niche models of the occurrence points detected.

## DISCUSSION

**Population differentiation.**—Our studies were necessarily based on few individuals, particularly in the case of the Veracruz population, the most recent specimen of which was collected in the 1930s (MLZ 22897). Nevertheless, our results show no evidence of differentiation among the two populations in the customary phenotypic dimensions: plumage coloration, size, and shape. However, we identify features of ecology that are distinct, and behavioral differences that are perhaps suggestive of population differentiation.

**Geographic distribution.**—The distributional points available for the two sheartail populations illustrate the broad geographic disjunction separating them, approximately 650 km (Fig. 1). Because no migratory behavior or movements are known for the genus, and given the broad ecological disjunctions, these populations almost certainly are genetically isolated, and have been for some time. The likely sister taxon of the Mexican Sheartail is the Slender Sheartail (*D. enicura*) found in scrubby montane forest in Chiapas and north-

ern Central America. A possible sister genus to *Doricha* (genus *Calothorax*) occupies much of the arid Balsas Basin and Oaxaca Valley (*C. pulcher*), as well as the Chihuahuan Desert of northern Mexico (*C. lucifer*), but has no contact with any of the populations of *D. eliza*. It is notable that several important segments of dry deciduous tropical forest (e.g., the entire western coast of Mexico) remain uninhabited by any sheartail-type hummingbirds. Some evidence exists (R. Zusi pers. comm.) that the sister genus to *Doricha* might not be *Calothorax* but rather *Calliphlox*, which would complicate biogeographic interpretations considerably. It also would emphasize the need for detailed systematic discussion (e.g., Howell and Webb 1995).

Our surveys of the Veracruz population indicate that its geographic distribution is  $\geq 50$  km away from that reported by earlier authors (López-Portillo et al. 1993, Howell and Webb 1995, Johnsgard 1997). This difference of information clearly springs from a variety of problems, including basing records on unclear locality descriptors. For example, the type lo-

cality originally was described as "Pau du Taureau, entra la Vera Cruz et Xalapa" (= Paso del Toro, between Veracruz and Xalapa; American Ornithologists' Union 1998). Currently, at least five sites in central Veracruz are called Paso del Toro, causing considerable confusion as to its exact location. One of these sites, near the city of Veracruz, at <50 m of elevation, possibly could be the source of confusion. Another of the localities called Paso del Toro is Xalapa, fairly close to sites where the species has been observed (H. Gómez de Silva, S. Aguilar, E. Ruelas pers. comm.). However, the original Paso del Toro (and apparently the actual type locality) was abandoned in the Nineteenth Century owing to an outbreak of leprosy; the remains of this pueblo, located in the Barranca de Naolinco, still can be seen (ROP pers. obs.). Other early specimens were labeled with little precision ("Jalapa" or "Veracruz"); only with the 1939 C. C. Lamb specimen (MLZ 22897) does a locality coincide with the species current observed distribution. Our highest elevation record for a Veracruz sheartail was 1,390 m, and no clear records place it even slightly higher in the vicinity of the city of Xalapa (1,400–1,600 m).

**Conservation.**—The conservation status of the two sheartail populations differs: one population is vulnerable whereas the other appears critically endangered. Both have extremely restricted ranges, and would qualify as "endemic" under the range-based definitions (Bibby et al. 1992), although this phenomenon is better termed "restricted range" (Peterson and Watson 1998). The Yucatan population, however, occurs in many areas under no immediate threat, and is present in at least three protected areas (Biosphere Reserves Ría Lagartos and Río Celestún, Special Biosphere Reserve Bocas de Dzilám de Bravo). Although the population is vulnerable, we recommend not according any formal status designation of threat or endangerment, although rapid development of the northern Yucatan Peninsula for tourism could change this situation.

The Veracruz populations, however, are found only very locally in a limited sector of central Veracruz. Their geographic distribution is centered within one of the largest foci of habitat destruction in the country, and the

dry deciduous forests that it inhabits are being rapidly modified for grazing, cane sugar cultivation, and other human activities. Central Veracruz has been a major focus of habitat destruction over the past several centuries, fragmenting the sheartail population's distribution from the onset. The distribution now centers on a single canyon, but the extreme rarity of specimens and reduced population suggest that the decline of the population may not result so much from present-day habitat fragmentation as from natural restriction of range. This phenomenon, however, certainly is exacerbated by ongoing habitat fragmentation. The recent introduction of goat grazing in the region poses a serious threat to the vegetation. For these reasons, we recommend that the Veracruz sheartail populations be considered critically endangered. Measures for their protection are urgently needed.

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## APPENDIX

*Specimens examined*.—Mexico, Veracruz, Jalapa, three males, one female (ANSP 23450, 37949, 37953; BMUK uncat.); Veracruz, 5 mi

N Jalapa, 4450', one female (MLZ 22897); Yucatan, 18 km E Dzilam de Bravo (type locality), three males (KUNHM 89383–5); 3.5 km S Progreso, two males (DMNH 18912, UMMZ 201853); Progreso, one male (LSUMZ 25123); Mérida (exact locality uncertain), one male (MLZ 25846); 3 km E Chicxulub Puerto, E of Progreso, four males, two females (DMNH 18907, 18908, 18909, 18910, 18911, 18913).